THE TONCOLARIUM – IMMERSIVE COLOR-MUSIC INSTRUMENT

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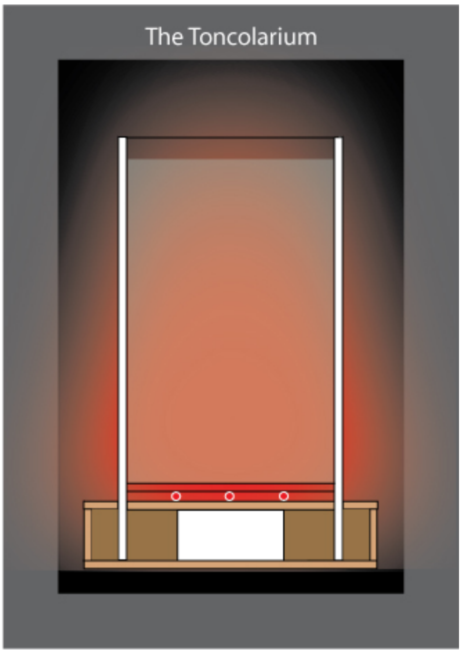

ABSTRACT

The Toncolarium is a hybrid. Built around a plexi glass container filled with water, it resembles an aquarium. It connects elements of two worlds – the real and the virtual. It combines colors and tones, light and sounds. The background of this artifact is an attempt to explore the phenomenon of synethesia and to follow the old tradition of experimental *color-music* instruments. Throughout the centuries artists and instrument makers have come up with many ideas on how to integrate music and colors. Among those instruments are the famous color organs, which formed an earlier tradition of *visual music* already back in 1725. The technological achievements in our modern days have made it possible to build advanced musical instruments that may integrate, generate and communicate colors and sounds in order to simulate a tone-color synesthesia. Probably such instruments can give greater inspiration to music composers and a deeper level of pleasure for the performers of music. 300 years of experiments may only have brought us to the dawn of the *color-music* instrument making.

1. INTRODUCTION

To approach the main concept of this contribution, a short historical survey, as well as three sources of inspiration, Louis Bertrand Castel, Alexander Wallace Rimington and Alexander Scriabin, is provided.

The French Jesuit monk Louis Bertrand Castel, credited to be the father of *color-music*, was inspired by Newton's theory that musical and color harmonies are related by means of the frequencies of light waves and sound waves. In 1725 Castel started to develop a color harpsichord in collaboration with the instrument maker Rondet. The instrument was called *Clavecin Oculaire* and had paper strips that appeared on top of the instrument when a key was pressed. The paper strips were lighted by candlelight [1].

The term “Color Organ” was first used in a patent application by Alexander Wallace Rimington in 1893. His three-meter-high color organ resembled a customary house organ with a cabinet of fourteen colored lamps on top. The light of the colored lamps could be adjusted to certain gradations of hue, brightness and saturation. This meant a tremendous progress compared to the paper strip harpsichords of the earlier centuries. Like most color organs, Rimington's instrument did not produce musical sounds. The color organ had to be played simultaneously with an organ that produced musical sound [2].

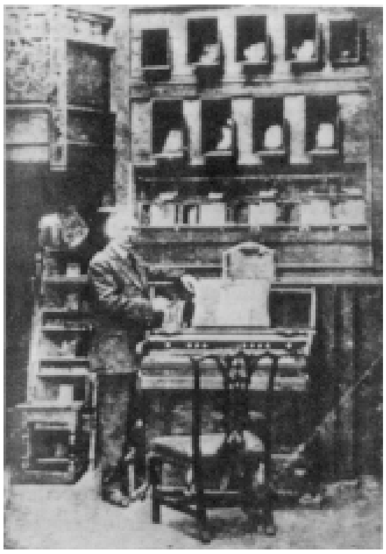

Figure 1. Rimington’s Color Organ.

The Russian composer Alexander Scriabin (1872-1915) started from a system of color-key correspondences instead of color-tone correspondences. He investigated the emotional aspects of synesthetic experiences of color during the change of one musical key to another. Scriabin’s color system was a thought-out system based on Sir Isaac Newton's *Opticks.* Scriabin's *Clavier à lumières,* also known as the *Luxe,* was played like a piano, but projected colored light on a screen in the Concert hall rather than sound. The original color keyboard, with its associated turntable of colored lamps, is preserved in his apartment near the Arbat in Moscow, which is now a museum dedicated to his life and works [3].

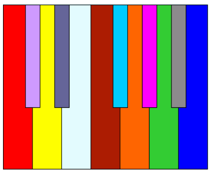

Figure 2. Scriabin's color system corresponding to the circle of fifths.

Other influences in the field of *color-music* are for example Kadinsky's *Der Gelbe Klang* and artists such as John Whitney, Oskar Fischinger and Mary Ellen Bute who pioneered the representation of sound in animated visual form.
Many interesting ideas of musical color scales have come up among different, often unrelated persons. As we can see in the table of color scales , for the most part, every one felt that the note "C" was red (Figure 3).

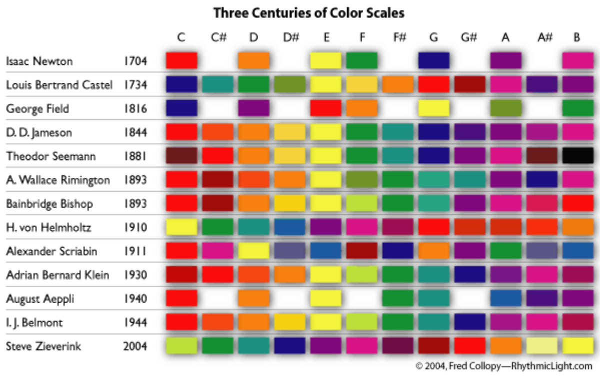

Figure 3. Three Centuries of Color Scales.

1.1. Synesthesia

The term "synesthesia" (or synaesthesia) means "senses coming together" (Greek: syn – together, aisthesis - perceive). It refers to the phenomenon in which stimulation of one sense modality implies a sensation in another sense modality. The most prevalent form of synesthesia is the phenomenon of seeing colors when hearing music or vowels, named *audition colorée* by the French psychologists [4]. It is estimated that synesthesia may be as prevalent as 1 in 23 persons across its range of variants [5]. Synesthesia is sometimes reported by individuals under the influence of psychedelic drugs, after a stroke, or as a consequence of blindness or deafness. A well-known early mention of sound-color synesthesia can be found in John *Locke's, An Essay Concerning Human Understanding (1689).* He tells about a blind man who made use of the explication of his books and friends and finally understood what scarlet signified. He said, *"it was like the sound of a trumpet"* [6]. There is rarely agreement amongst synesthetes that a given tone will be a certain color. However, consistent trends can be found, such that higher pitched notes are experienced as being more brightly colored. Also in our everyday language we have these common sensory associations. Musical tones can be high or low, and they can be dark or light, even straggly. Rock music can be both heavy and hard. Jazz can be cool and positive. A tone can be rich and warm or cold and metallic, just as a drawing can be made of warm colors and another made of cold colors.

1.2. Aims

The question here is: What makes certain combinations of colors or notes more pleasing to us than others?
Of course, this is also a question about culture. Music in the far-east is structured very differently than in the west. This is also true of color. Combinations of color that are found in places like India or Africa are very different than that of central Europe. To keep it simple, the decision is to focus on western culture and music, and to approach the matter in a practical manner. The core aims of this work include the following main activities: 1) build a *color-music* instrument, 2) use computer software to translate the musical information to colors.

2. CONCEPT

The main approach was to build an instrument around a physical substance that could more naturally integrate sounds and colors. Instead of playing on a plain keyboard and look at a flat screen, the player shall be able to feel the depth of the sounds and the ocean of colors. Water may here be considered as an interesting medium.

2.1. Colored water?

Figure 4. The Nile turns to blood – *The Ten Commandments* (1956) [9].

To use ink or water-color to colorize water could be an interesting effect, but the water would quickly be turbid and darkened. No miracles here yet... (Figure 4). Contrary to painters who make use of physical paint, music composers always deal with an immaterial

"substance". Music is therefore often viewed as the highest art. But colors in the form of light approach the immaterial state and thus come very close to the realms of sounds and music. Colors in freed form will also introduce mobility in time, rhythm, and combination, slow or rapid and varied. When Sir A. Wallace Rimington introduced his color organ, he said: *"There has, in fact, been no pure colour art dealing with colour alone, and trusting solely to all the subtle and marvellous changes and combinations of which colour is capable as the means of its expression. The object of the present invention is to lay the first stone towards the building up of such an art in the future."* [7]
Therefore a decision was to let colors in the form of light stream up into the water from underneath.

The next challenge was to find a way to let the light spread in the water container and diffuse nicely. High intensive LEDs with wide angle dispersion are now available. LED is a very efficient light source. They are small and have a long life. They are here to revolutionize the *color-music* field, by being incorporated into the music instruments.

Figure 5. LEDs make the surface change colors dynamically to stimulate the guests at Lufthansa Buisness-Lounge in Terminal 2 at Munich's airport [10].

Figure 6. Metropolis Mall Entry Feature 100 foot 2800 GPM waterfall with color changing LED fixtures on eight foot letters. (Plainfield, IN, USA) [11].

2.2. The Toncolarium

The name Toncolarium reveals the basic concept of this instrument – the relationship between musical tones and colors, known as *tone-color* synesthesia. The ending part *-arium* refers to a box or container that holds something - in this case a concept of *color-music.* It can also be associated with the term aquarium. Like an aquarium, the Toncolarium is filled with water and that plays a vital role for it in order to work.

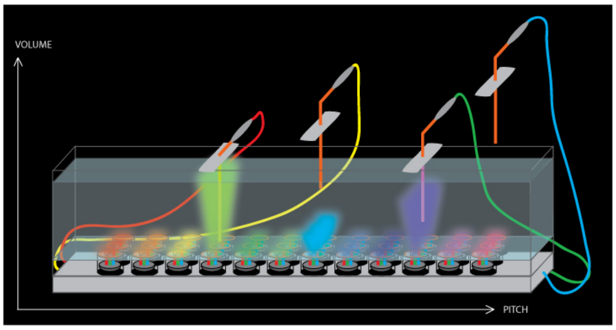

Figure 7. The Toncolarium.

The Toncolarium is made of plexi glass filled with water. The size is 150*300*1200 millimeters. The instrument is controlled by four L-formed user control tools. A metal thread is placed on the outside of each tool, from the bottom and all the way to the handle, where a colored cable connects it to a microprocessor underneath. In the bottom of the water are 12 ellipse formed metal rings, one in each row, and they are also connected to the microprocessor. The distance between a control tool and a metal ring determines the amount of resistance. Tapped water gives a suitable resistance for the instrument. By putting, and thereby immersing, a control tool into the water, LEDs underneath the water are turned on and the water area above is lighted up with a specific color. The player controls the amount of light by how deep into the water a control tool is immersed. The deeper it's immersed the stronger the light will be, causing louder volume to have a brighter light. The control tools can be placed and hold at a certain depth by movable rubber bolts attached around them resting at the edge on the top of the Toncolarium. Each of the twelve rows of LEDs is controlled from a computer, so the color for that row can be changed to any color-value in the RGB-scale instantly. A sound is played when a control tool has contact with the water. The area above each of the twelve rows can be assigned to trigger a unique sound. Each one of the four control tools can activate anyone of the twelve contact areas in the bottom and all four control tools can be used simultaneously, making it possible to create complex chords. The player controls the volume of a sound by how deep into the water a control tool is immersed. The deeper, the louder the sound will be.

2.3. Target groups

The Toncolarium is meant to create an ambient atmosphere and stimulate the color–musical sensation. According to Scriabin the presentation of the right color corresponding with music works as *"a powerful psychological resonator for the listener"* [8].

2.3.1. A music instrument

The target in focus here is first of all the performer. The main purpose of this project is not to bring a spectacular lightshow to an audience, but to give the performer or composer a stimulating approach to the instrument in order to enhance creativity. Matching colors will here enrich the improvisation and composing phase in several ways. Just like new sounds, chords, tensions or melody phrases inspire and open up new possibilities, colors in the form of light will help and guide the improviser/composer to find new ways to combine the elements, combinations that he had not thought of before.

2.3.2. An interactive installation

A light atmosphere which has been formed by colors can help people to relax, so the Toncolarium can also be used for color and sound therapy. By letting algorithms control the changes of sounds and colors automatically, the Toncolarium could be a perfect artifact which will reduce tension in for example a waiting room.

2.4. Interaction

The Toncolarium has two basic operation modes: PLAY and PERFORMANCE.

2.4.1. PLAY mode:

Each of the twelve contact areas has a color that corresponds to a tone. Both the tone and color scale can be changed in the computer program so the synesthete can tune the instrument to fit him personally. This can be down manually or by letting complex algorithms automatically control the relations between pitch, amplitude, color and light intensity.

2.4.2. PERFORMANCE mode:

In performance mode, the instrument's twelve channels are divided in two sections: eight tracks for musical sound loops and four tracks to control overall tempo, individual track speed and DSP effects. A sound starts playing in a loop when a performer is immersing a control tool into the water, and the corresponding LEDs underneath is also turned on. Both track volume and light intensity are controlled by how deep the controller tool is immersed.

2.5. Output and input

Two microprocessors handle the inputs and outputs.

2.5.1. Sounds:

The data from the instrument (depth value and tone number) is sent to a microprocessor under the instrument. The microprocessor is connected to a computer via USB. The incoming values are converted to midi data in a computer program. In *play* mode, sounds are produced by virtual midi instruments. In *performance* mode, the sounds come from midi files and audio files especially composed for the show.

2.5.2. Colors:

Color	Tone	R	G	B
	B	100%	-	50%
	A#/Bb	100%	-	100%
	A	50%	-	100%
	G#/Ab	-	-	100%
	G	-	50%	100%
	F#/Gb	-	100%	100%
	F	-	100%	50%
	E	-	100%	-
	D#/Eb	50%	100%	-
	D	100%	100%	-
	C#/Db	100%	50%	-
	C	100%	-	-

Figure 8. A basic rainbow RGB-color scheme

A second microprocessor is used to output values from the computer program to the twelve rows of LEDs. The Toncolarium make use of 36 LEDs (9400 mcd) with an angle dispersion of 40°. All colors in the RGB-scale can be generated (See Figure 8). However, the colors are not fixed. The values in percents can be changed easily from the computer program. Since every LED is a full-range RGB LED, it's possible to generate dynamic changes of colors, not only in the horizontal position but also in the vertical position of the instrument.

2.6. Computer animated colors and graphics

A second aim was to use computer software to translate the musical information to colors on a computer screen. A technical description of how the finished system works is here provided.

The incoming data from the Toncolarium (depth value and tone number) are sent from Max/MSP to Processing by using the Maxlink. Processing is used to generate all the computer graphics and colors displayed on the screen. Each of the four control tools controls a color object (Figure 9).

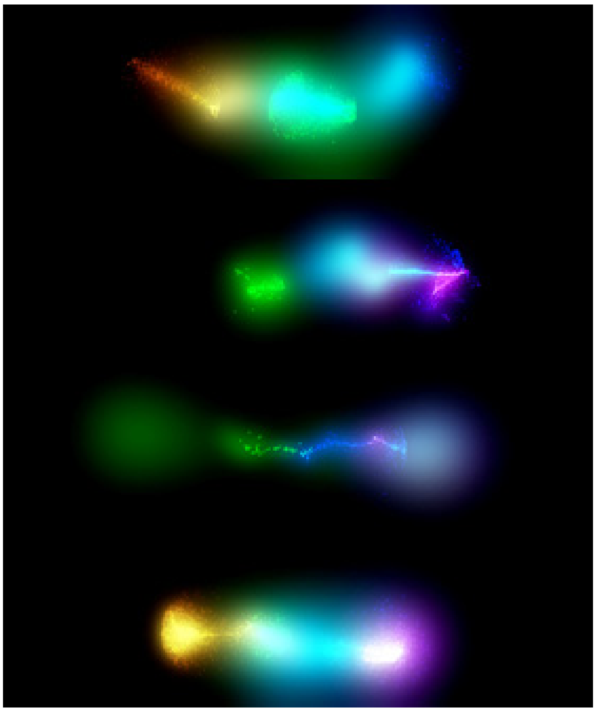

Figure 9. Red light = lower tones, Green light = lower-middle tones, Blue light = upper-middle tones, Violet light = upper tones

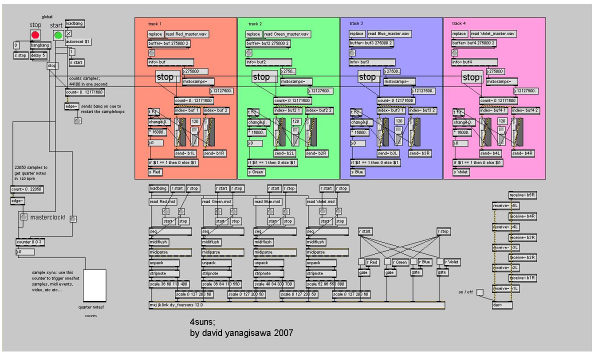

Figure 10. Max/MSP with Maxlink sending values to Processing.

2.6.1. Special composed music for a demonstration

Midi files of type-0 are loaded into the “seq”-objects in Max/MSP. The same melodies recorded as audio files are synced to the midi files. Midi velocity values are connected to y-position variables in the Processing sketch and midi pitch values are connected to x-position variables. The audio signals are converted to floats in Max/MSP and control the size of the objects appearing in the Processing window. All pre-made music are composed in Steinberg’s Advanced Music Production System, Cubase 4. Before exporting as individual sound files, each audio track is trimmed and optimized so they will fit nicely together. See example video file *“4suns.mov”* [12].

The Toncolarium is used to play live with the recorded music or solo. Four tools control the LEDs (amount of light and colors). Values are sent to Max/MSP and generate sounds from VST-instruments. The output is the same as for the pre-recorded files, so the four user tools can also control the four “sun”-objects in the Processing window.

2.6.2. Computer systems and equipments

Max/MSP [1]
Processing [2]
Maxlink library [3]
Arduino [4]
Other: Soundcard, MIDI Keyboard, Laptop and Projector

3. CONCLUSION

The idea to make use of water as a medium to generate music isn’t new. There has also been many artist and musicians who have been experimenting with music and colors. The Toncolarium is a mix of both these concepts. A prototype made of plexi glass and plywood is now under construction. The idea to use water as a medium for signals controlling audio and light has been tested, and the result is very satisfying. Ordinary tapped water is a sufficient conductor for this purpose. There is no need to add chemicals or salt to the water. The Toncolarium is built around a small, fast and affordable (open-source) physical computing platform, Arduino (See Figure 11). The Toncolarium incorporates two of them, one for input signals and a second to control the small high intensive LEDs, which are being better and better and are a perfect match for a *color-music* instrument. It is possible to control both sound and color output in one program (Max/MSP), making it easy to try new combinations of tones and colors. The instrument is limited to twelve tones, which equals one octave if the chromatic 12-tone scale is used. Two octaves would have made the instrument more musically playable and attractive. But the instrument would also have been twice as long. However, the Toncolarium is only a prototype and might expand in the near future. Computer animated colors and graphics in Processing which react on musical information have also been tested. An example is provided which shows how both midi and audio information can be used to control shape and motion of colors, and how colors can be blended and added together to form abstract multi colored patterns.

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[1] A graphical environment for music, audio, and multimedia by Cycling74. http://www.cycling74.com/

[2] An open source Java based programming language for images, animation, and interactions. http://www.processing.org/

[3] The MaxLink Java libraries enable communication between Processing and Max/MSP. http://jklabs.net/maxlink/

[4] An open-source physical computing platform http://www.arduino.cc/

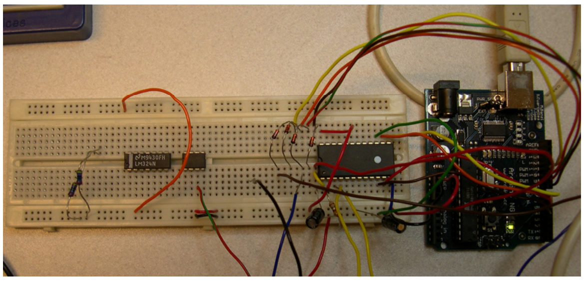

Figure 11. The Arduino board connected to the four user controller tools and twelve contact areas in the bottom of the water.

As a music instrument, the Toncolarium is meant for experimentation only, and is not meant as being a final solution. As an interactive installation, it will do a great job to create a relaxing atmosphere and reduce tension in for example a waiting room at the dentist or physician.

3.1. Future development

For future developments my intention is to try to give answers to the following questions. How would a *color-music* instrument for the 21-century look like? How can colors and sound interact and be perfectly integrated into one single instrument?
How about a synthesizer or digital audio workstation that besides generating sounds, displays colors in real-time, and lets the composer create his own shapes and colors for each sound or track and control their motion in the sequencer, just like midi and audio. How about translating notes, chords and rhythmical patterns to colors and shapes, and to be able to print them just like scores?
There can be several practical advantages to use colors and shapes in combination with music. For example, it can help students to learn the language of music quicker by memorizing the relationships of the colors.
Music instruments with built in LEDs can stimulate students at the first learning phase, and help them to quicker understand where the tones on the instrument are placed and how to find them.

The Interactive Sound Design program at Kristianstad University has made it possible for me to explore this fascinating field of science and there still remains a lot to learn. I would like to thank electro technician Åke Bermhult for invaluable help with the prototype.
My hope is that this project will continue and that my experiences will be shared at the ICMC 2007 conference and performances.

4. REFERENCES

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[9] Cecil B. DeMillés, *The Ten Commandments,* (1956)

[10] Arnold AG (Friedrichsdorf, Germany), Lufthansa Buisness-Lounge in Terminal 2 at Munich’s airport, 2003

[11] Atlantic Fountains, Musical fountains in Metropolis Mall, Plainfield, IN, USA, http://www.atlanticfountains.com/musical.htm

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